Prehistoric Lithic Technology, Workshops, and Chipping Stations in the Philippines

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THE PHILIPPINE ISLANDS represent an important area for research of problems concerning prehistoric archaeology in Southeast Asia. These insular areas, located east of the biogeographic boundary known as Huxley's line, include a variety of tropical environments. These islands remained detached from the continental portion of Southeast Asia throughout the Pleistocene and Holocene. Archaeological research has documented human occupation and adaptation from at least the Late Pleistocene and Early Holocene within these islands.

Unfortunately, relatively little intensive prehistoric archaeological research has been undertaken in the Philippines compared to some areas in mainland Southeast Asia, Oceania, and Australia. Warren Peterson's dissertation (1974) focused on a series of sites in northern Luzon and represents one of the foundation studies in the Philippines for modern archaeology. Peterson's work has often been cited and his conclusions used for the development of models concerning prehistory in the Philippines and Southeast Asia.

Peterson's research was conducted during a period when behavioral reconstructions from site assemblage analyses were prominent in archaeological research. Specifically, Peterson attempted behavioral reconstruction from the analysis of stone tools from the Busibus/Pintu site in northern Luzon, Philippines. A reanalysis of the entire Busibus/Pintu lithic assemblage has revealed problems with Peterson's initial analysis and interpretation of this site—problems that will be addressed in this paper. Lithic technology, stone tool manufacture, and selection and reduction strategies will also be explored. Finally, new interpretations of the nature of the lithic assemblage and site activities at Busibus/Pintu rock shelter will be provided.

The Busibus/Pintu site is located on the Ngilinan River, northern Luzon, Philippines (Figs. 1, 2). The site was excavated by Peterson in 1968–1970 (Peterson 1974 : 1). Peterson analyzed the lithic assemblage for traces and patterns of use wear (1974 : 15–70). He concluded that many of the lithic materials recovered displayed patterned use wear and polishing typical of knives, choppers, scrapers, awls, hand-adzes, hand-axes, burins, gravers, saws, and other implements. Among

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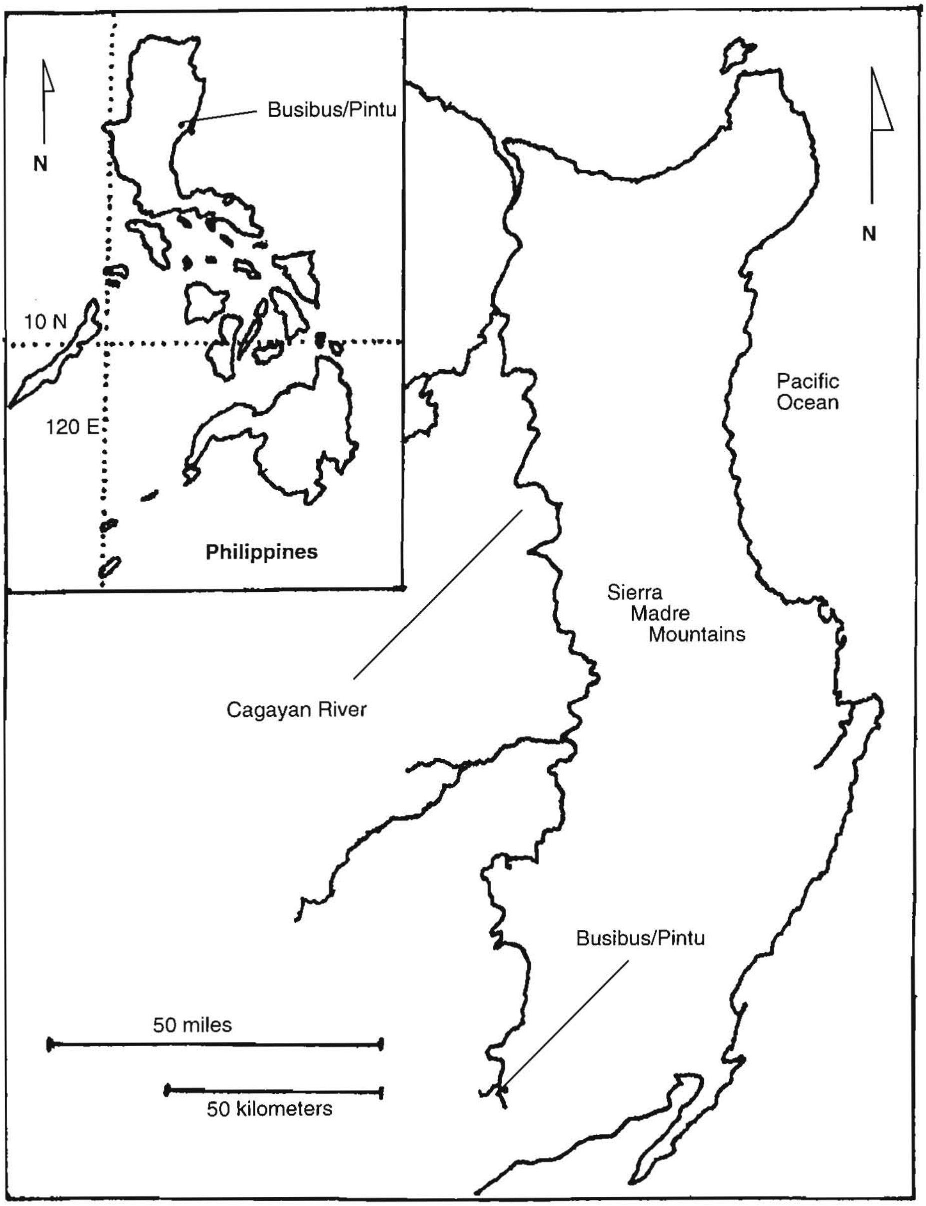

Fig. 1. Busibus/Pintu rock shelter site, northern Luzon, Philippines.

the other implements, he included Sumatraliths, a unifacial discoidal stone implement made from a modified river pebble (Higham 1989 : 37), which has been connected to Early Holocene Hoabihnian stone-working traditions in insular and mainland Southeast Asia (Peterson 1974). Peterson (1974 : 82–117) further suggested that these tools were used for working wood, bone, animal hides, and bark cloth and for butchering by hunters and collectors who intermittently frequented the site from about 4000 to 1400 B.P. Peterson assumed that these

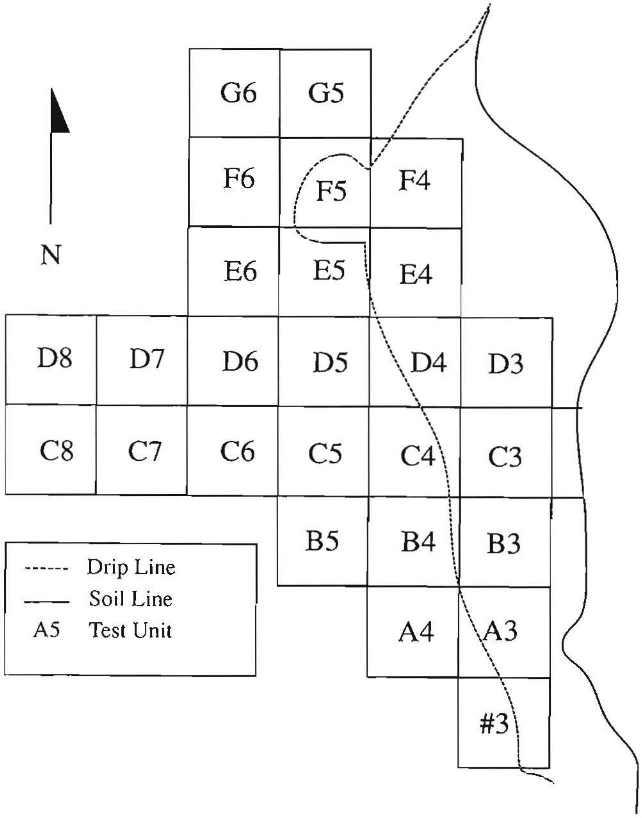

Fig. 2. Excavation unit layout of Busibus/Pintu (from Peterson 1974).

groups, composed of domestic units rather than select subgroups or specialized task groups, used the site as a residential camp or habitation in which a variety of daily activities were performed. The lithic assemblage from the Busibus/Pintu site was reanalyzed (Latinis 1995) to assess Peterson's conclusions. I am unable to confirm many of his interpretations.

I suggest that the Busibus/Pintu site may have been the location for the selection of a variety of desired and suitable lithic raw materials as well as a chipping and/or reducing station or workshop (sometimes referred to as manufactory) for the opportunistic manufacture of core tool preforms made from water-worn basalt pebbles and cobbles. "Quarry site" is also a common designation for this kind of site, although *quarry* implies that raw material was extracted from the earth rather than selected from a stream bed or gravel bar. These core preforms resemble groundstone adze and chisel preforms, based on morphological similarities. However, no *finished* core tools were recovered from this site.

There is also evidence that other raw materials, such as jasper, chert, and chalcedony, were selected, tested, and reduced to remove potentially flawed aspects (e.g., cortex and nonhomogeneous portions, veins, bands, or inclusions within the parent material) and to lighten bulk weight. This procedure would have facilitated the further transport of these raw materials and would also have allowed optimal quality raw material to be transported. Greater amounts of adequate raw material by weight could have been transported with less cost using this strategy.

Manufacture of tools made from lithic raw material other than basalt, or even significant use of tools from the nonbasalt raw materials, did not take place at this site, with two exceptions. The first exception is the presence of a few fist-sized jasper pebbles and pebble fragments that show evidence of extensive surface battering and may have been used as hammerstones or pounding implements. The second exception is the presence of 27 small volcanic glass flakes, which may have come from a retouched or resharpened volcanic glass tool. Only one of these flakes, however, has slight evidence of use damage. Given the scarcity of this raw material in the lithic assemblage, this material may have been derived from an exotic source. That is, the volcanic glass flakes may result from the use, modification, or resharpening of a tool that was brought to the site for a limited time. It is likely that volcanic glass was not locally available; in any case, it seems not to have been selected for reduction and use near this site. All other raw material in the assemblage is thought to be ubiquitous in the area and readily obtainable from the nearby gravel bars and stream bed (Peterson 1974).

A total of 3912 lithic pieces were recovered from the site, for a combined weight of 129.8 kg. This is the entire currently known lithic assemblage. Most of these pieces appear to be industrial waste from the preparation of the core preforms. No hearths were mentioned by Peterson (1974), though fire-cracked rock is present in the assemblage. Earthenware sherds were recovered from the first five layers, including one partially complete bowl with a ringstand. A significant amount of nonhuman bone material was also recovered. This faunal material has been recently examined by Karen Mudar (Mudar 1995). The species present include deer, pig, water buffalo, macaque, python, and a soft-shell turtle. Many of these species may have reached the Philippines independent of human introduction by the Mid- to Late-Pleistocene. Peterson (1974:114) stated that although flotation was used in the initial excavation, no plant material was recovered. However, seed remains were recently recovered in residues from many of the storage bags. Some of these seeds may be a species of *Canarium*. Peterson (1974: 105–114) also mentioned the presence of antler points, bone fragments with carved V-shaped points, keel-shaped bone needles, two glass beads, and a ceramic spindle whorl. None of these has been located in the assemblage, with the exception of the two glass beads and the ceramic piece thought to be a spindle whorl.

Although this site may indeed have been intermittently used by groups of hunters and collectors as a frequentation/camp site, the evidence from the lithic assemblage points to another interpretation. The reanalysis indicates that the lithic assemblage was the product of specialized task groups that frequented the site for intervals long enough to select nearby raw materials, to test and reduce some of these raw materials for further transport, and to manufacture preforms (most likely small adze preforms) for further transport to different locations. The finishing, usage, redistribution, and/or discard of these tools would have taken place at these different locations. Furthermore, the strategy used for the production of these preforms incorporated the selection of raw material in a form (having desired natural features and surfaces) such that minimal modification and percussion flaking would yield an adequate preform. I refer to this strategy as an opportunistic selection and reduction strategy. However, "opportunism" may not be a sufficient label for such strategies employed in lithic tool selection and manufacture unless the term is explicitly defined.

OPPORTUNISM

Opportunism in regard to lithic raw material selection and tool production is a complex topic. It is difficult to equate opportunism with a strategy by which the least amount of time and/or energy is expended in preform production. Which is more economical: to select raw materials based on desirable features (such as shape and specific surface features) so that minimal percussion flaking would be required to manufacture an acceptable preform regardless of breakage risks during manufacture? Or to select raw material based on other qualities of the rock so that greater success is guaranteed in roughing out preforms? How is risk of breakage during manufacture assessed? If the economical use of time and energy is an important criterion for stoneworkers, then how much is invested in the selection of raw material versus the success rate of preform manufacture? Many factors are involved in this decision process, including quality and distribution of raw materials, quantity of raw materials, flakability, workability, and so forth. Although there is no easy way to quantify opportunism, an assessment through qualitative descriptions can be very useful for understanding such strategies.

Andrefsky (1994) explores stone tool production in relation to abundance and quality of available lithic resources. Andrefsky's conclusions are drawn from ethnographic studies in Australia and archaeological examples from North America, and have implications for what might be considered opportunistic reduction strategies. Andrefsky defines two classes of tools. *Informal,* or *expedient,* tools are those on which little effort has been expended in production. *Expedient* and *opportunistic* are often used interchangeably, which can lead to definition problems; these terms should be explicitly defined by the investigator when referring to lithic assemblages. Informal tools are thought to be associated with less mobile or sedentary groups (Andrefsky 1994 : 22) for a variety of reasons, including lower amount of energy and work required for production. Tools on which more effort is expended in production are called *formal* tools. These include bifaces, retouched tools, formally prepared cores, tools that are hafted, and other composite tools. Formal tools are thought to be associated with more mobile groups (Andrefsky 1994 : 22) for several reasons, including advance preparation, anticipated use, and transportability (Torrence 1983 : 11–13).

Andrefsky (1994 : 31) concludes that both formal and informal tools may be used by sedentary and mobile groups in similar relative frequencies. This would be consistent with an assumption I make: that mobility configuration alone does not necessarily determine the nature of lithic technology, although there are certain logistical restrictions; for example, repetitively transporting large lithic tools, such as grinding stones or anvils, for long distances would probably not be feasible. Andrefsky (1994 : 30) found that both formal and informal tool production occurred when lithic quality and lithic abundance were high; that primarily informal tool production occurred when lithic quality was low, regardless of abundance; and that primarily formal tool production occurred when abundance was low and quality was high. Andrefsky (1994 : 31) notes,

> If all other variables are held constant, quality and abundance of raw materials may structure stone tool production in a predictable manner. Low-quality raw materials

> tend to be manufactured into informal tool designs ... high quality raw materials tend to be manufactured into formal kinds of tools.... The quality and abundance of lithic raw materials played a direct role in prehistoric tool makers' decisions to produce various types of stone tools.

Peterson (1974) suggests that raw material is ubiquitous, thus abundant, in the area of the Busibus/Pintu rock shelter. The raw material available, from observations of the lithic assemblage only, is of both high and low quality. With the exception of volcanic glass, high-quality raw material is not scarce. We might therefore expect to find both formal and informal tools. Thus, analysis of the materials should show a seemingly opportunistic strategy as well as a more formal, intricate strategy. Opportunism is here defined as informal tool production. Yet if no tools other than tool-producing implements, such as hammerstones, occur at this site, this may be difficult to test. However, adze or adzelike preforms do occur and fall under the definition of formal tools. The debitage from the raw materials other than basalt may indicate that prepared cores were being manufactured and transported away from the site. A prepared core would also be treated as a formal tool. Finally, the volcanic glass remains likely came from a retouched tool, another formal tool. Thus, the entire assemblage may be the product of manufacturing or maintaining formal tools. If opportunism is equated with informal tool production, then opportunism was not part of the lithic reduction strategies used by work groups at the Busibus/Pintu site. As I shall show, however, opportunistic selection and reduction strategies can be applied to both formal and informal lithic tool production technologies.

If opportunism is defined, instead, as any strategy incorporated so that minimal manufacture is required to produce an acceptable tool, regardless of what class of tools is being produced, then it may be possible to observe several patterns in the lithic assemblage from Busibus/Pintu. The number of trimming flakes per preform should be rather low, indicating that suitably sized and shaped raw materials were available and selected. Also, a high percentage of cortex flakes should be present if a core-blank rather than a flake-blank strategy was used. Trimming flakes from a flake blank would possess less cortex, as most of the original surface would likely have been removed in preparing the material for blank removal. A large portion of trimming flakes from a core blank would have cortex, especially if the parent blank was a pebble or cobble of only slightly larger dimensions than the final product.

There are various levels at which opportunism can be expressed in lithic technology: flakes removed during the reduction process, the selection of pebbles and cobbles used to manufacture tools, and the location and creation of camps and settlements where stone tools were manufactured.

Although the dominant activities at the Busibus/Pintu site may have centered on the selection and reduction of a variety of lithic materials and the preparation of basalt preforms, it is likely that the task groups that frequented this site took the opportunity to acquire other resources and engage in other activities as well. Incidental activities certainly occurred, since the work party had to live at the site long enough to perform their tasks. The recent examination of the faunal evidence may indicate that hunting forays occurred near the site as well (Mudar 1995). Mudar notes that the site contained both high- and low-meat-bearing bones from a variety of species. It is unclear whether this finding indicates residential habitation (characterized by a greater concentration of high-meat-bearing bones), a base camp for hunting parties (characterized by a greater concentration of low-meat-bearing bones, with high-meat-bearing bones assumed to have been transported away from the site), and/or provisional strategies (transporting and storing food and other resources). In light of the faunal evidence, it is reasonable to assume that the work parties took the opportunity to hunt animals in the vicinity and to procure other resources as well. However, the use-damage analyses of the lithic assemblage indicate that butchering activities at this site did not employ the lithic materials recovered during excavations. I suggest that the evidence of the faunal and lithic analyses indicates that the work parties used provisional strategies as well as opportunistic hunting activities in which animals were butchered and processed away from the site.

LITHIC ASSEMBLAGE

The majority of the raw material present, by both gross weight and total count, was basalt (including andesite). The basalt is fairly hard, homogeneous, and of good quality. Further investigation of the exact physical properties of the basalt, as well as compositional analyses, is in progress. Large phenocrysts are notably absent. About 75 percent of the material is medium- to fine-grained (having a textural coarseness similar to a fine-grained sandpaper, from No. 300 to No. 1000 grit). Some pieces are glassy and smooth.

Chalcedony, jasper, chert, and volcanic glass were present for only a combined 4.4 percent by weight and 20.1 percent by count of the total lithic assemblage. The 27 volcanic glass flakes and flake fragments appear to have been derived from the same source and possibly the same tool. Two of these pieces from different layers (layer 3 and layer 6) were refitted. This has implications for the temporal distinctions or the validity of the natural layers in Peterson's (1974) initial report. These flakes and fragments resemble by-product flakes from the remodification or resharpening of a tool. The combined weight of the volcanic glass is only 0.02 percent of the entire assemblage.

All pieces were examined with a low-powered microscope at a minimum of 20x magnification. Many pieces also were examined using higher magnifications. There was virtually no use damage present on flakes, flake fragments, or other related forms. Only three basalt flakes, two volcanic glass flakes, and three of the other flakes had evidence of possible use wear: only 0.2 percent of the lithic assemblage by count. Of these eight pieces, only one volcanic glass flake had evidence of definite use wear. The damage patterns on all pieces were a series of lunate microflakes, 1–5 cm in length, that ran along the cutting edge. This pattern is typical of pieces used for cutting deeply or scraping with a perpendicular force into a medium or hard contact material. The relative hardness of the contact material could not be determined with any accuracy.

No significant edge rounding or other wear patterns were detected on the basalt flakes. Most of the basalt flakes, flake fragments, and indeterminate chunks are industrial waste products from the manufacture of basalt preforms. Damage patterns on these flakes support this conclusion. Some flakes were probably derived from hammerstone and anvil modification and damage. However, many pieces exhibited damage patterns that resulted from discard, trampling, improper storage, and/or improper transport and handling. This type of breakage can be mistaken for use damage (Young and Bamforth 1990). These damage patterns were readily detected under a low-powered microscope. Recent breakage was easily detected due to the discoloration and lack of weathering on the recently exposed or fractured surfaces, as well as the erratic breakage patterns and locations of such breakage on the examined pieces.

The most common wear patterns present in the assemblage were battering, pitting, bruising, and crushing on surfaces of large pieces. These patterns are typical of implements used for pounding, hammering, and crushing. These pieces were likely hammers or anvils used on blanks and preforms for flake removal. Most of these implements were comparatively coarse-grained, though several dense, hard, and fine-grained pieces were present. Also, three jasper pebbles had battered damage over their entire surface. The damage pattern is typical of hammerstones. It is not known if these jasper pieces were used on specific raw materials or indiscriminately.

Seven basalt and andesite pieces averaging about 390 g apiece showed an unusually large pitted or "divoted" damage pattern (Fig. 3). Each of these pieces had from one to several divots (usually no more than five) on one or several surfaces. These divots were circular, concave, pitted depressions about 2–3 cm in diameter. The inside surfaces were rough, similar to coarse sandpaper. The depressions were not ground into the surface of the rock, but rather were the result of repetitive, perpendicular force applied to a concentrated area. These pieces resemble andesite seed crackers (used for breaking open the hard shell of *Canarium indicum* seeds) and have wear patterns similar to those of artifacts recovered from archaeological sites and current processing sites in eastern Indonesia (Latinis and Stark 1994). Several of these pieces were fractured or split through the divoted areas. This was likely due to the repetitive shock and stress in a concentrated area from extensive, long-term usage.

No significant redundant forms or shapes of flakes were observed. About 40 percent of the flakes were irregular in shape. The remainder were distributed evenly among expanding (trapezoidal and triangular), converging (trapezoidal and triangular), rectangular, circular, and semicircular forms. Metrical measurements of the flakes fell on a continuum rather than into specific size and weight classes. Most flakes were relatively light and small (Table 1).

The basalt flake assemblage contained significantly greater amounts of cortex

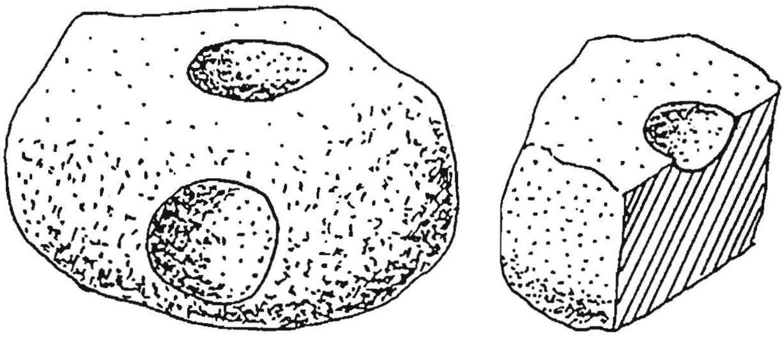

Fig. 3. "Divot" pattern on large pieces.

Table 1. Metrical Measurements of Basalt Flakes

		STANDARD DEVIATION
Flake width (cm)	2.919	1.663
Flake length (cm)	2.856	1.480
Flake thickness (cm)	0.827	0.504
Platform breadth (cm)	1.865	1.239
Platform thickness (cm)	0.655	0.433
Weight/mass (g)	10.813	16.978

(more than 70 percent had cortex present). Of the remaining raw material, with the exception of volcanic glass, about 47 percent of the flakes had cortex present. The cortex and damage patterns on the basalt flakes indicate that flakes were removed from a water-worn river cobble or pebble in a circular manner (Fig. 4). This formed the sides and initial bevel of the preforms. Minimal flake removal apparently produced adequate preforms. Patterns resulting from flake analyses of the other raw materials indicate that erratic cortical surfaces and potential flaws (usually nonhomogeneous surfaces resembling cortical surfaces) were removed.

MORPHOLOGY, FORM, AND ARTIFACT CLASS

The morphological and form analysis helped place the artifacts within specific classes; it is referred to as "type" in Table 2. This analysis indicates that a large quantity of industrial waste in the form of basalt flakes and flake fragments dominates the lithic assemblage (Table 2). There is a considerable number of basalt artifacts, which are more indicative of a lithic chipping station or workshop than of a butchering station or multiprocessing residential site. These artifacts include pounding implements, preform rejects, broken preform fragments, blanks, and anvils. No grinding stones are present. This indicates that the final products, thought to be groundstone adzes, were not completed at this site. There are many hammerstones, damaged pebbles, and pebble chunks. Some of the damaged pebbles may be rejected blanks or used hammerstones. There are also the seven artifacts mentioned above that show the unique "divot" pattern.

All other raw materials are characterized by the presence of only flakes, flake fragments, and indeterminate chunks. The damaged jasper pebbles are the only exceptions. The extremely high percentage of flakes, flake fragments, and indeterminate chunks may be indicative of the testing, flaw removal, and weight reduction of certain raw materials for further transport and tool manufacture at different locations. There are almost no used flakes or other tool types present.

No retouched tools were observed. Only the preforms and a few indeterminate pebble blanks had indications of having been worked. It is unlikely that tools other than preforms and some modified pounding implements were manufactured at this site.

SPATIAL DISTRIBUTION

Spatially, the industrial waste material and implements were not evenly distributed throughout the site. Instead, there are large concentrations of industrial waste

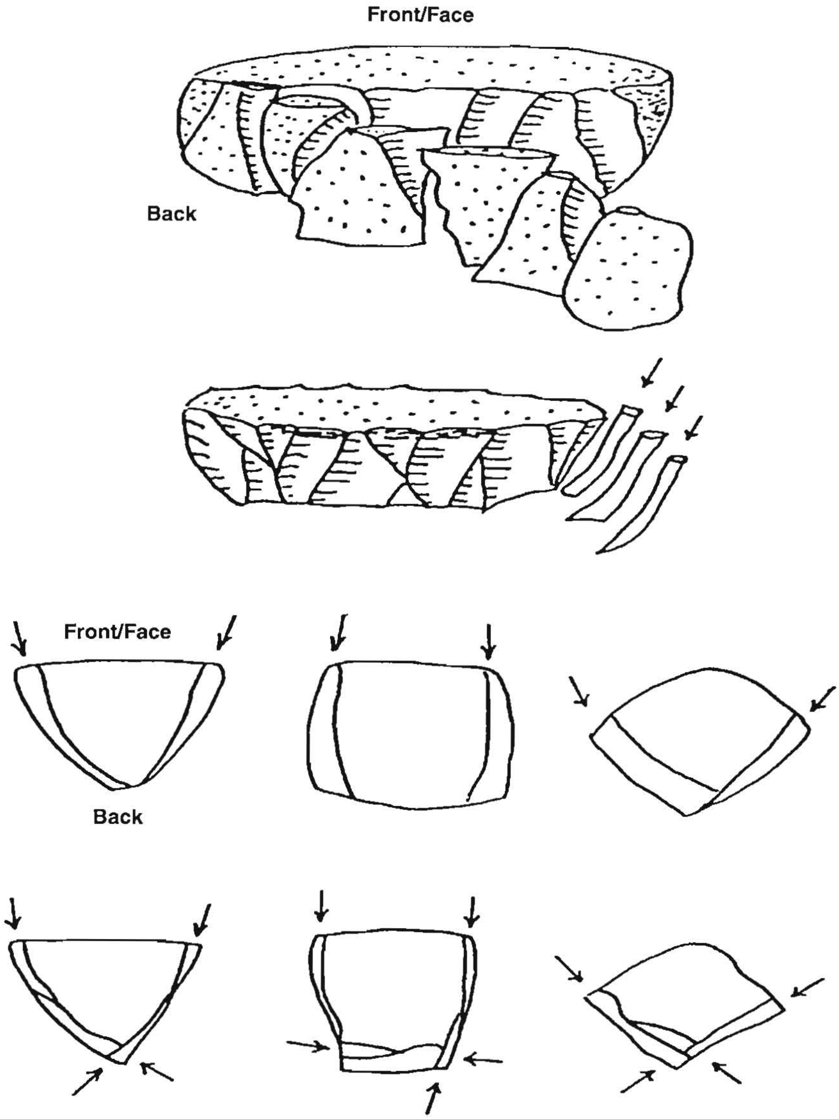

Fig. 4. Flake detachment pattern for core preforms.

material and tools in specific areas (Figs. 5, 6). This probably resulted from the use of specific areas for heavy reduction, while other areas may have been convenient for further trimming. There were larger concentrations of light pieces within the drip line of the cave. Units A3 and #3 are good examples. Each had close to 900 pieces, but the average piece weighed only 7.6 g and 14.8 g respectively. Units D4 and B3 each had more than 400 pieces with averages of only 11.4 g and 4.5 g respectively. Smaller concentrations of heavy pieces occurred outside the drip line. Unit E6 had only 24 artifacts, yet the average piece was 236.1 g, while B5 had 29 pieces with an average of 103.4 g. Unit C8 had only 2 pieces at an average of 189.4 g.

Table 2. Counts, Weights, and Percentages for Raw Materials by Types

TYPE	COUNT	% SAMPLE	WEIGHT/GRAMS	% SAMPLE	AVERAGE PIECE/GRAMS
Basalt					
Flakes	1,897	61.47	26,790.99	21.59	14.123
Flake fragments	640	20.74	1713.890	1.38	2.678
Preform fragments	82	2.66	12,401.54	9.99	151.238
Hammerstones	30	0.97	9833.300	7.92	327.777
Damaged pebbles	120	3.89	40,680.82	32.78	339.007
Hammerstone fragments	46	1.49	5133.000	4.14	111.587
Indeterminate pebbles	49	1.59	10,451.54	8.42	213.297
Indeterminate pebble chunks	82	2.66	4749.500	3.83	57.921
Indeterminate chunks	97	3.14	7927.820	6.39	81.730
Indeterminate	35	1.13	1692.167	1.36	48.348
Pieces with divots (125)	7	0.23	2722.000	2.19	388.857
Unknown (33)	1	0.03	0.630	(0.001)	0.630
Total	3,086	100.00	124,097.2	99.99	40.213
Chalcedony					
Flakes	203	45.01	1385.320	52.14	6.824
Flake fragments	199	44.12	605.890	22.80	3.045
Indeterminate chunks	49	10.87	665.870	25.06	13.589
Total	451	100.00	2657.080	100.00	5.892
Jasper					
Flakes	72	36.92	562.410	22.93	7.811
Flake fragments	98	50.26	364.965	14.88	3.724
Damaged pebbles	1	0.51	287.700	11.73	287.700
Indeterminate chunks	24	12.31	1237.505	50.46	51.560
Total	195	100.00	2452.505	100.00	12.577
Chert					
Flakes	52	50.49	349.300	58.62	6.717
Flake fragments	40	38.84	88.080	14.78	2.202
Indeterminate chunks	11	10.68	158.470	26.60	14.406
Total	103	100.01	595.850	100.00	5.785
Volcanic glass					
Flakes	26	96.30	29.132	94.18	1.120
Flake fragments	1	3.70	1.800	5.82	1.800
Total	27	100.00	30.932	100.00	1.146

Several factors may have contributed to these patterns. First, the exterior of the cave may have been an area for initial roughing out and heavy working with large hammers. This location also produced large industrial waste products. The interior of the cave may have been an area for trimming and thinning in which smaller flakes were the major industrial waste product. Second, the task groups may have made a periodic clean-up of the work floor in the interior of the site. The larger, heavier waste material may have been redeposited from the cave interior to the exterior. Perhaps the industrial waste was pushed or discarded to the outside of the cave mouth. Third, the lighter pieces outside the drip line of the

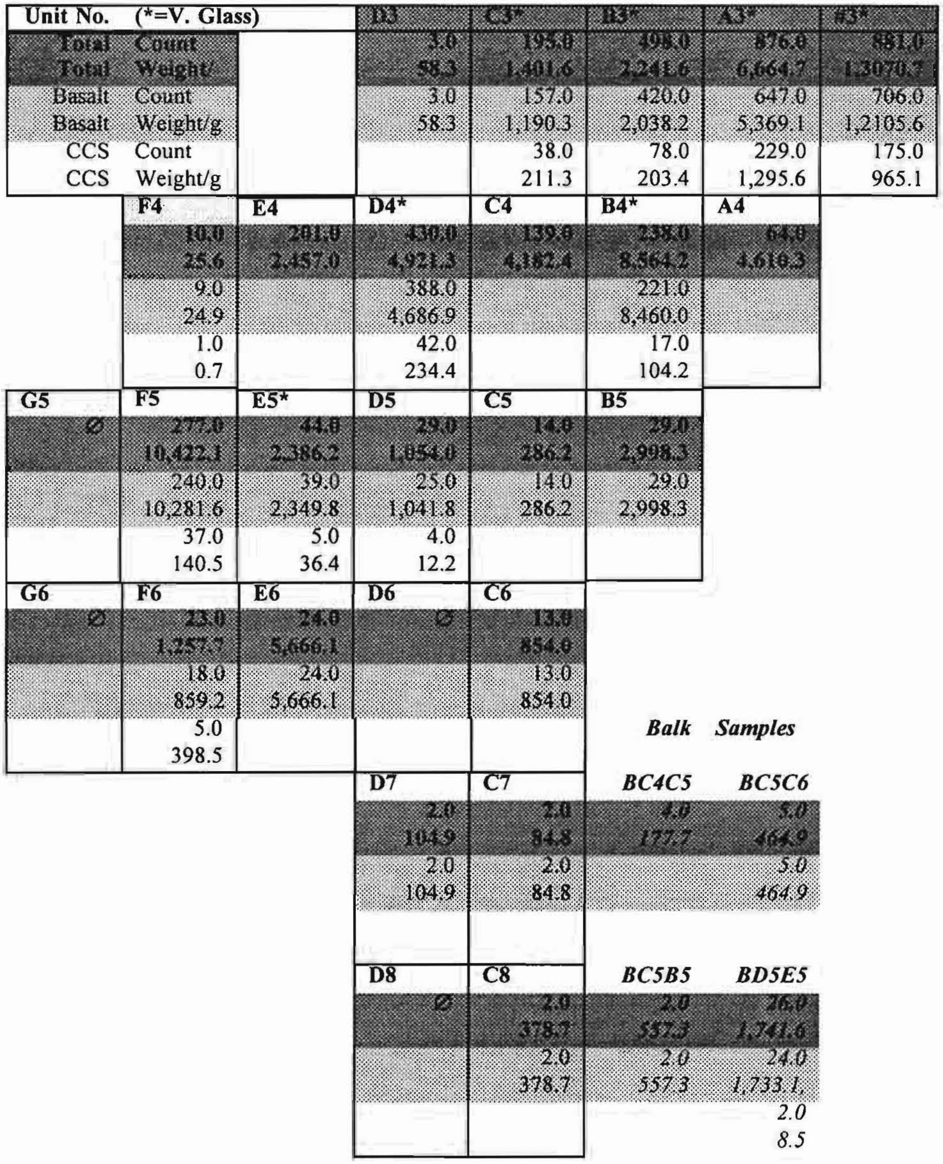

Fig. 5. Spatial distribution of artifacts by units.

cave may have been transported from the site through erosional forces. This area is exposed to outside elements, such as rain, which may have had a tremendous impact in the form of postdepositional disturbances. Heavier pieces would be less likely to move. The remains inside the drip line of the cave were not subject to this kind of postdepositional process, so the small, light pieces would have remained. If the cave floor was indiscriminately used for both heavy and light work, and if debris was not subsequently removed, the number of large pieces

Unit No. (* = V. Glass)
Avg. Wt/Pcs (All Materials)
Avg. Wt/Pcs Basalt

			D3 **19.4g** 19.4g	**C3*** **7.2g** 27.6g	**B3*** **4.5g** 4.9g	**A3*** **7.6g** 8.3g	**#3*** **14.8g** 17.1g
	F4 **2.6g** 2.8g	**E4** **12.2g**	**D4*** **11.4g** 12.1g	**C4** **30.1g**	**B4*** **36.0g** 38.2g	**A4** **72.0g**	
G5 Ø	**F5** **37.6g** 42.8g	**E5*** **54.2g** 60.3g	**D5** **36.3g** 41.7g	**C5** **20.4g** 20.4g	**B5** **103.4g** 103.4g		
G6 Ø	**F6** **54.7g** 47.7g	**E6** **236.1g** 236.1g	**D6** Ø	**C6** **65.7g** 65.7g			
			D7 **52.5g** 52.5g	**C7** **42.4g** 42.4g			
			D8 Ø	**C8** **189.4g** 189.4g			

Fig. 6. Spatial distribution of average artifact weight by units.

should be somewhat evenly distributed. However, relatively few large pieces were found in the interior of the cave.

TEMPORAL DISTRIBUTION

The temporal distribution of lithic materials is difficult to determine in view of the lack of provenience information and the discrepancies in the accuracy of what information of that nature is available. Furthermore, some pieces from different layers were refitted. It is likely that some of the stratigraphic layers recognized by Peterson are actually a single layer. Different natural layers may also represent a single work floor. Finally, intermixing of materials from different layers may have occurred through postdepositional disturbances. This must be kept in mind when assessing temporal changes by comparing the natural layers.

However, it appears that the bulk of industrial material was deposited in layers 7–3. Lithics trail off dramatically in layers 2 and 1 (Tables 3, 4). With the exception of layers 2 and 1, and the questionable layer 3.5, basalt represents more than 90 percent by weight of the assemblage in each layer. The other raw materials occur in such low frequency that it is unwarranted to suggest any change in targeting or availability of these raw materials from layer to layer.

Distribution of lithic types by layer does not indicate any significant change in industrial activity or major technological change from layer to layer. The preform analysis likewise does not indicate any technological change, although the small sample size makes the identification of technological, morphological, or stylistic changes problematic. It is difficult to determine if the changes in the amount of material per layer indicate significant changes in degree of production or the total quantity of preforms produced over a given interval. There is at present no way to tell how long each layer of the site was occupied and used. The radiocarbon

Table 3. Total Counts and Percentages of Raw Materials by Layer

	BASALT	NONBASALT	CHALCEDONY	JASPER	CHERT	VOLCANIC GLASS	TOTAL
Total counts							
Layer 1	1	3	1	2	0	0	4
Layer 2	61	18	7	4	6	1	79
Layer 3	501	74	18	24	30	2	575
Layer 3.5	7	6	3	3	0	0	13
Layer 4	757	84	18	49	13	4	841
Layer 5	278	94	62	19	8	5	372
Layer 6	798	322	247	48	21	6	1120
Layer 7	255	56	45	10	1	0	311
Layer 8	16	3	1	0	2	0	19
Percentages							
Layer 1	25	75	25	50	0	0	100
Layer 2	77.22	22.78	8.86	5.06	7.59	1.27	100
Layer 3	87.13	12.87	3.13	4.17	5.22	0.35	100
Layer 3.5	53.85	46.15	23.08	23.08	0	0	100
Layer 4	90.01	9.99	2.14	5.83	1.55	0.48	100
Layer 5	74.73	25.27	16.67	5.11	2.15	1.34	100
Layer 6	71.25	28.75	22.05	4.29	1.88	0.54	100
Layer 7	81.99	18.01	14.47	3.22	0.32	0	100
Layer 8	84.21	15.79	5.26	0	10.52	0	100

Table 4. Total Weights and Percentages of Raw Materials by Layer

	BASALT	NONBASALT	CHALCEDONY	JASPER	CHERT	VOL. GLASS	TOTAL
Total							
Layer 1	34.40	19.10	3.10	16.00	0	0	53.50
Layer 2	2722.19	441.62	57.40	348.20	35.00	1.02	3163.81
Layer 3	6908.97	330.57	82.85	106.82	139.60	1.23	7239.47
Layer 3.5	129.90	43.40	30.70	12.70	0	0	173.30
Layer 4	14,891.53	386.83	71.83	258.29	54.72	1.99	15,278.36
Layer 5	7466.25	518.90	351.77	124.19	33.54	9.40	7985.15
Layer 6	18,102.79	1802.13	1433.81	259.065	101.01	8.245	19,904.92
Layer 7	15,036.94	306.02	251.67	48.95	5.40	0	15,342.96
Layer 8	1812.46	9.70	1.40	0	8.30	0	1822.16
Percentages							
Layer 1	64.30	35.70	5.79	29.91	0	0	100
Layer 2	86.04	13.96	1.81	11.01	1.11	0.03	100
Layer 3	95.43	4.57	1.14	1.47	1.93	0.02	100
Layer 3.5	74.96	25.04	17.71	7.33	0	0	100
Layer 4	97.47	2.53	0.47	1.69	0.36	0.01	100
Layer 5	93.50	6.50	4.41	1.56	0.42	0.11	100
Layer 6	90.95	9.05	7.2	1.30	0.51	0.04	100
Layer 7	98.01	1.99	1.64	0.32	0.04	0	100
Layer 8	99.47	0.53	0.08	0	0.46	0	100

dates can only be safely used to provide an estimate of the duration of overall site use. It is doubtful that these dates represent the earliest and latest dates of site use.

PREFORM ANALYSIS RESULTS

All the preforms with perhaps one exception were reduced from a core. It seems that opportunistic selection of raw material as "instant" blanks was a prominent strategy employed by the stoneworkers in choosing materials for reduction. Specifically, they chose river pebbles and cobbles that conformed to the desired shape of the preform. Cobbles and pebbles with desired features and surfaces may have been split or broken in a manner that provided suitable blanks as well. Thus, minimal trimming flakes along the sides, back (in some cases), and butt (in some cases), and the creation of a bevel by the removal of a few flakes or blades, were all that was required to produce a preform. The technology of blanks made from flakes does not appear to have been used by the stoneworkers at this site.

In all cases, the face or front surface of each preform retains the cortical, water-worn surface of the parent pebble. In many cases, the butt and back of the adze preform are composed of water-worn cortical surfaces of the parent pebble as well. This may have been done to take advantage of a naturally smooth surface, so that extensive grinding could be avoided. Perhaps trimming all surfaces was judged too difficult or risky (for example, the risk of transverse fracture), or perhaps this surface provided a suitable face and platform for further reduction so that minimal trimming flakes would yield an acceptable preform. Opportunism of this nature has been noted for other sites in Oceania (Best 1974 : 228, 234; Cleghorn 1982 : 82; Jones 1984*b* : 251, 260; Leach and Whitter 1990 : 66; see also Leach and Leach 1980 : 99). Jones (1984*b*; see also Jones 1984*a*) presents a model for opportunistic adze manufacture that accords with the evidence from this assemblage. The key lies in the search for raw material of suitable form so that minimal flaking is required to manufacture preforms (Jones 1984*b* : 252).

The preforms mostly fall into two morphological types by shape, cross section, dimensions, and flaking pattern (Figs. 7, 8). These types may have different functional qualities. Other types may be present, as indicated by a few atypical preforms in the assemblage. However, these pieces were too weathered or fragmented to draw definite conclusions. Furthermore, the total sample size of preforms is too limited to accurately determine the full range of types.

The first type is generally rectangular or oval in plan view when viewed from the back or front. The cross section is reverse triangular or reverse trapezoidal. The face or front of the preform is entirely the flat cortical surface of the parent material. A series of flakes were removed from the sides using as a platform the front and/or back edges. The bevel was created by removing flakes from either side of the blank and a few small blades at the cutting edge.

The second type usually expands from the butt toward the cutting edge when viewed from the back or front of the preform. The cross section is often diamond-shaped or triangular. The face or front of the preform is completely composed of the cortical surface from the parent material. Again, a series of flakes was removed from the sides using the front edges as a platform. However, the bevel appears to have been more crudely formed by the removal of one or two large flakes from the cutting edge. In some cases, it is unclear whether these were intended to be

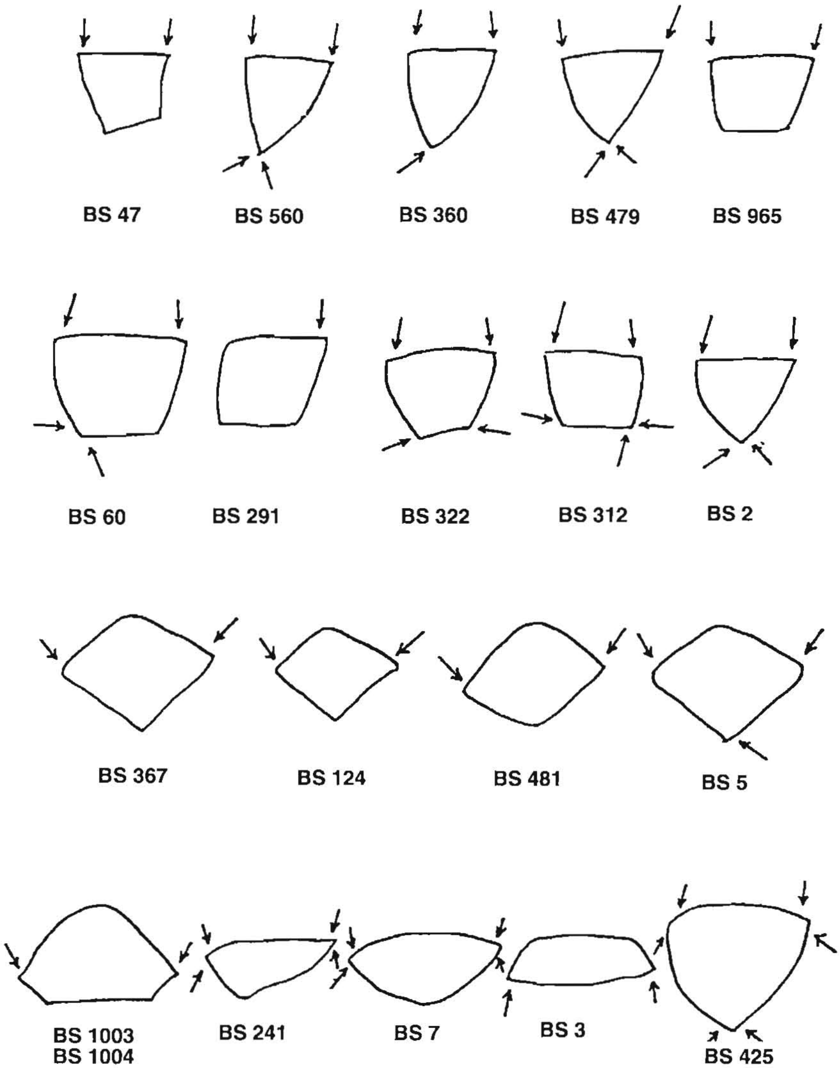

Fig. 7. Cross sections and flaking patterns for preforms (arrows indicate direction of force at location of flake removal).

beveled cutting edges; these bevels may have been only the result of transverse fracture.

These two dominant types of cross sections may represent two separate functional classes of adzes. Best (1984: 390–391) claims, "The cross section of an adze is a direct expression of the blade shape and the intended function of the tool." A curved or gouge-shaped edge would be suitable for concave surfaces, while a straight edge would be more suitable for a flat or convex surface (Best 1984: 391). There are clearly at least two classes of edges expressed by the two types. The first type has a flat or straight cutting edge, while the second type has a curved V-shaped cutting edge. Furthermore, the tapering toward the butt of some of the preforms may also be a functional design. It alters the morphology,

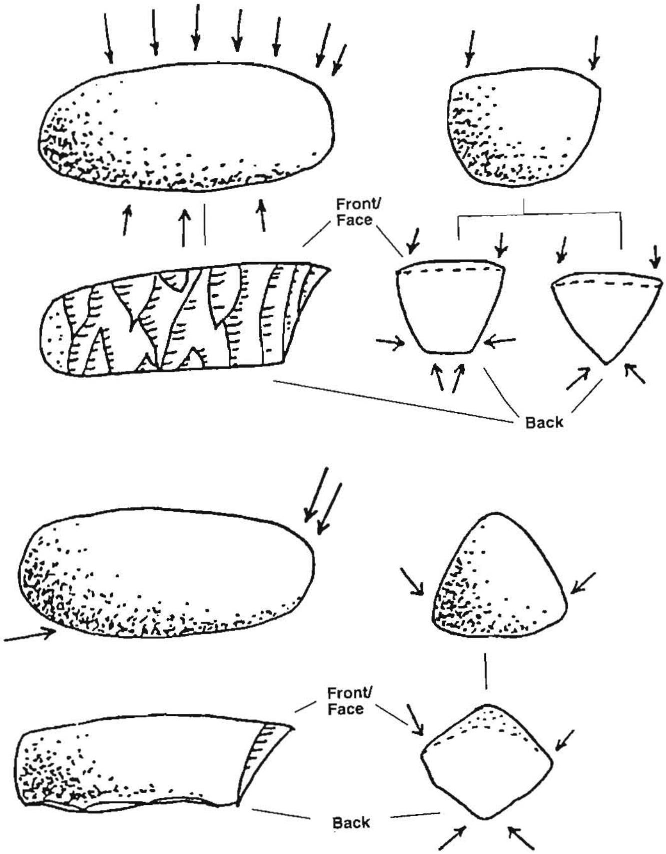

Fig. 8. Reduction of pebble blank to preform (arrows indicate flake removal pattern).

which may have varying effects, and it also alters the mass, center of gravity, impact force distributions, and potential force of the preforms. These factors may have specific consequences for the overall function and effectiveness of the final product. I do not want to give the impression that every alteration of the preform necessarily has a functional intention behind it. Still, it is important to recognize that such alterations do have functional implications.

One preform in the sample may have been derived from a cortical flake but resembles the second morphological type. One preform has a complete trilateral flaking pattern and an oval-triangular cross section. Finally, one preform has evidence of minor flake removal on the cortical face, which extends about 1 cm from either side. The edges were used as the platform. In a few other cases, flakes may have been removed longitudinally from the butt using the butt as a platform.

Most stone from which preforms were derived has a relative coarseness of medium, medium-fine, or fine. This indicates that relatively medium- to fine-grained basalt was targeted for preform manufacture. This also accords with the flake analysis. However, some coarse-grained preforms appear to have been attempted as well. This finding is based primarily on the flake information, although a few blanks and possible rejected preforms have a coarser grain as well. It may be, however, that most of the coarse-grained flakes resulted from damage to hammerstones and anvils rather than from preforms.

In all cases, it appears that initial trimming flakes were removed from the sides and bevel first, then from the butt. Shaping the sides and bevel may have been the riskiest part of the reduction process. Thus, attention may have been given to the removal of flakes from these areas as an initial part of the reduction process (Leach and Leach 1980 : 116). All the preforms have a unilateral bevel. Most show evidence of undesired protuberances, excessively deep flake scars, or transverse fractures; nearly one-half show evidence of transverse fracture. These are likely factors for their rejection. No evidence of grinding, polishing, or use damage is present on any of the preforms.

The angle at the intersection of the cutting edge and face (for most preforms), coupled with slight convex curvature of the face, indicates that the adzes made from these preforms "potentially" could have been used to remove large amounts of wood, not necessarily as an axe (Best 1977 : 315). They may have been designed for fairly heavy-duty, general-purpose work (Best 1977 : 314). That is, the preforms or adzes might suffer intermediate stress somewhere between total axial stress and total bending stress. This means that the resulting adzes, depending also on other properties of the stone, could be an effective and durable general-purpose wood-removing tool. This contrasts with adze kits that may have been designed for ritual purposes (see Jones 1984*b* : 248; Leach 1993 : 41, for further information concerning adzes with symbolic or ritual purposes) or more specific projects, such as canoe manufacture. However, it must be stressed that the Busibus/Pintu examples are likely discarded preforms and not finished products. The final morphology of a finished adze may have been quite different from the preforms after undergoing considerable morphological changes (Leach and Leach 1980 : 120; Weisler 1990 : 34). Some of the preforms were totally flat at the face with the bevel beginning at this point. These generally appeared as if the bevels were not yet formed when the piece was rejected or discarded. In other cases the bevel angle had been formed and appeared as if it was only awaiting final grinding. In such cases, the angles may have been quite close to the desired results.

The preforms seem relatively small overall compared with preforms from other sites, especially in Oceania, such as Tataga-Matau, Samoa, and Mauna Kea, Hawai'i). However, comparative collections may be biased toward larger, more complete, and ritual forms. The average weight was 156.3 g; the average length, 9.5 cm; average thickness, 3.0 cm; and average width, 3.8–4.5 cm. The average number of flakes removed from the more complete pieces was 12.8. It appears that the production of massive preforms did not take place at this site. The flake analysis indicates that larger forms may have been manufactured, although these forms were probably not significantly larger than those represented.

One explanation for the relative smallness of the preforms in this site may be that these preforms represent a demand for small, "household" adzes required for everyday tasks (Weisler 1990 : 46) rather than those needed for larger projects. However, there may have been simply no desire or need for larger forms.

Kuhn (1994) discusses several aspects of mobile tool kits that may have some implications concerning tool size. Kuhn (1994 : 436) suggests that transport costs and potential utility guide the design and assembly of transported tool kits. He further suggests that the most efficient transport option is to carry many small tools (only about 1.5 times their minimum usable length) and perhaps one or a few cores. Although the cores or large tools do not add significantly to the overall cost efficiency (and may decrease it), large tools, because of functionally different aspects such as total mass and potential force, are sometimes preferred for different tasks. Thus, small adzes may be part of more mobile tool kits. To increase an adze's mobile efficiency, a reduction in total mass and size would be appropriate.

However, Kuhn refers to lithic tool kits from North America, Europe, and Australia. The nature of lithic tool kits from Southeast Asia may be quite different. It would be more useful to compare complete tool kits, which may be quite different in Southeast Asia when adding in wooden and other nonlithic aspects of the complete kits. Furthermore, caching and provisional strategies may be significantly different. Mobility may be deceptive to disentangle using only lithic tool-kit analyses. It is almost certain that high mobility is maintained through a continuum of strategies by different groups in various environments. A specific processing site may have a set of lithic tools characteristic of a sedentary group. However, this may be a processing station with cached tools specifically designed and used by highly mobile groups. Generally, it would be preferable to take into account the entire mobile tool kit and not just the lithic tool kit when discussing the "mobility" of any tool kit.

Andrefsky (1994) has noted that other factors, especially abundance and quality of raw material, have a great influence on the design of lithic tool kits. This may challenge Kuhn's reasoning that transport costs and potential utility guide the assembly of mobile tool kits. However, these are not necessarily mutually exclusive. Abundance and quality of raw material, coupled with transport costs, potential utility, and other factors, may guide the design of the lithic tool kits.

The calculation of the maximum number of preforms manufactured at this site is based on the total number of flakes and flake fragments divided by the average minimum number of flakes removed from the more complete preforms. The number of preforms potentially manufactured at the site is 198. Therefore, if the preform fragments represent the total of the unsuccessful pieces (82), then the number of successful preforms may be approximately 116. This gives a success rate of about 60 percent. This level of success may actually be quite high in view of the nature of the raw material, which may be more readily subject to transverse fracture. Minimal flake removal may then be a necessary strategy to reduce the chances of end shock.

As for opportunism, it appears that an opportunistic strategy was employed so that minimal flaking of locally available resources yielded acceptable preforms. Opportunistic strategies, however, may have been operating at multiple levels of the total procurement and manufacturing process. In view of the evidence given above, it seems that an absolutely high success rate may not have been important for the stoneworkers who frequented this site.

Given Peterson's statements, it is assumed that raw material was locally ubiquitous, so that the stoneworkers could easily find suitable pebbles or cobbles (in many cases as instant blanks). Thus, they may not have needed to be particularly careful about the success rate of their reduction strategies. There is little evidence of conservation and recycling of either preforms or reduction tools at this site. A few preforms may have been reused as hammers, as indicated by damage patterns.

The absence of larger rejects may indicate that some recycling did occur. However, conservation and recycling do not appear to have played a significant role in the overall strategy of preform manufacture at this site.

The suitability of form of the parent material appears to have been an important, if not critical, criterion for preform manufacture. Thus, parent material or blanks were selected from the locally available range of cobbles and pebbles rather than quarried from an outcrop, shaped, or roughed out. The shape of the preforms closely matches the selected blank. Preform faces were left as the original cortical surface of the blank. This may have been an opportunistic feature of the overall strategy, which reduced the workload in producing acceptable preforms. It may also have been a strategy intended to compensate for poor, difficult, or risky flakability of local raw materials. Future replication experiments using the same raw materials would help considerably to clarify these issues.

One specific definition for opportunism that I offer concerning the Busibus/Pintu assemblage is a strategy that exploits the ubiquity of the available raw material (assuming that raw material is more or less infinitely available for the stoneworkers) as well as the form of the raw material, in such a way that the overall workload of preform manufacture is reduced by manufacturing preforms that require minimal percussion flaking thanks to the selected form. I wish also to emphasize that an opportunistic strategy may be employed in selecting raw material. This differs from opportunistic strategies employed in flake removal and stone tool manufacture. I do not imply that opportunism in this context is necessarily equivalent to informal or expedient tool manufacture. There will be a point at which the energy invested in selecting a blank and the energy invested in flaking a preform will coincide to a minimum such that x amount of energy expended searching for blanks and y amount of energy expended manufacturing a preform will be mutually minimized. While it is unlikely that such absolute minimums were ever achieved, they are important components in setting acceptable levels of time and energy expended in preform manufacture.

LITHIC ANALYSES AND DISCUSSION

Reanalysis of the Busibus/Pintu lithic assemblage raises several concerns regarding lithic analyses and interpretations of sites elsewhere in the Philippines. There are not only problems concerning the ability of archaeologists to reliably identify use damage (Young and Bamforth 1990) but also specific problems with identifying use damage and the nature of contact materials when working with basalt assemblages (Richards 1988). These considerations have often been overlooked.

Young and Bamforth (1990) conducted a test of the "no magnification" approach to microwear analysis. Their results indicate that this approach likely produces inaccurate and biased data (Young and Bamforth 1990: 404). The success rate for archaeologists to correctly identify altered but unused flakes was a discouraging 25 percent. Their data (Young and Bamforth 1990: 406–407) resulted in the suggestion that "archaeologists often misidentify edge damage on the edges of flaked stone artifacts as evidence of use because they do not consider processes other than use that might have produced that damage." Other processes that may cause damage include trampling, movement damage, postdepositional disturbance, sediment conditions, weathering processes, improper excavation techniques, improper transport of artifacts, improper handling, and improper storage. The resultant damage to lithic assemblages can easily be mistaken for use damage. Young and Bamforth (1990) further suggest that archaeologists fail to consider other processes that cause damage to lithic artifacts and that most lack systematic training in the practical aspects of stone tool analysis and the ability to correctly identify lithic damage patterns.

Richards (1988) notes more specific problems when conducting analyses of basalt assemblages. Very few use-wear studies have been conducted on basalt assemblages (Kamminga 1978; Odell 1980; Price-Beggarly 1976; Richards 1988; Schutt 1982; Stafford 1977). Comparing damage patterns typical of other material, such as cryptocrystalline rock, with damage patterns on basalt poses problems. Patterns of use wear on basalt and andesite are less distinguishable due to their often grainy or coarse (nonvitreous) composition. Edge rounding on these materials is quite variable in occurrence. Although the used areas of a tool can be very accurately identified using low magnification, microflake scars and their characteristics (for nonvitreous basalt) are difficult to observe and distinguish. These have implications concerning the identification of tool action and the relative hardness and nature of contact materials. Interpretations along these lines should be approached with caution. It may be unwarranted to make specific inferences and interpretations concerning tool action and contact materials when dealing with basalt and andesite assemblages.

Additionally, there has been a vast amount of research, including new analytical techniques and strategies for data collection, since the early 1970s in regard to lithic technology, quarries, chipping stations, workshops, reduction strategies, and resource procurement strategies. The work that has been done in Oceania, particularly in Hawai'i and New Zealand, over the past few decades on similar sites has resulted in a considerable amount of comparative data and interpretations that are useful for studies in other areas as well. However, relatively few studies of prehistoric lithic collections have been conducted in the Philippines and surrounding areas in Southeast Asia.

Most studies in the area concerning adzes and basalt assemblages have relied heavily on a handful of typological studies. These studies often were based on morphological types derived from complete and finished tools. These tools were often obtained from burial or ritual contexts, or museum collections that may be biased toward these contexts. Also, much of the previous work in Southeast Asia has focused on continental areas or localities that were attached to the mainland during the Pleistocene. Insular areas, such as the Philippines, eastern Indonesia, and parts of Melanesia, have received little attention. Thus, artifacts such as Sumatraliths were often the only comparative material available.

The criteria for determining utilized flakes and tools were misleading. Peterson remains quite vague concerning criteria and description, although he goes into detail concerning patterns of use wear for stone tools (Peterson 1974). Other studies of similar material have suffered from insufficient criteria for determining utilized flakes and tools (Ronquillo 1981). Studies such as Ronquillo's based the definition of "utilized flake" on any flake having a suitable cutting edge or sharp edge (Ronquillo 1981 : 6) rather than any flake having damage patterns characteristic of a utilized flake. There are serious problems with this classification. Flakes that have a suitable cutting edge or sharp edge may have "potentially" usable edges that may or may not have been utilized. Flakes that have damage patterns characteristic of utilized flakes are likely to be utilized flakes. The flake assemblage from the Busibus/Pintu site had thousands of flakes with potentially adequate cutting edges. However, the reanalysis of 3912 pieces yielded only 8 flakes with possible and 1 with definite use damage. A large portion of the Busibus/Pintu assemblage had evidence of breakage that resulted from processes other than use. Such damage can easily be mistaken for use damage.

Finally, Peterson assumed that the Busibus/Pintu site was used by groups of hunters and foragers. The site resembles what would have been considered a residential habitation site for these groups. Peterson may have been looking for evidence in the lithic assemblage that accorded with a priori assumptions about the nature of lithic tool kits used by such groups. This problem may fall in with other paradigmatic problems in archaeology stemming from the early 1970s.

CONCLUSION

In light of the results from the recent reanalysis of the Busibus/Pintu lithic assemblage, it seems likely that this assemblage is primarily the industrial waste products of a lithic workshop. Included in the waste assemblage are other indicators that the manufacture of core tool preforms made from basalt took place at this site, as well as the selection and partial reduction of other raw materials. These indicators include pounding implements, partially reduced cores, and a handful of core tool preforms. The preforms were manufactured from selected water-worn cobbles and pebbles as core blanks that closely match the resultant morphology and metric dimensions of the preforms. Natural features of the parent rock were opportunistically used in such a manner that minimal flake removal yielded adequate preforms. The preforms and other raw materials were not reduced to finished forms at this site. These unfinished forms were likely transported to other locations, where they are assumed to have been finished, redistributed, used, and/or discarded. This contrasts significantly with Peterson's (1974) earlier interpretation of this as a residential site in which tools were produced and used. It is more likely that this site was used by specific task groups.

Provisional strategies and opportunistic strategies were likely used at various levels. This is evident in light of the ceramic and faunal assemblages. There is also evidence that other incidental activities took place. These may include the processing of nearby resources, such as nuts for food, as well as hunting forays. These activities may have been part of an opportunistic strategy operating at a different scale. However, the definition of *opportunism* needs further attention. There are also problems with inferring mobility configurations using only the nature of the lithic assemblage.

Finally, I wish to address the issue of the lack of documented lithic workshops, quarries, and chipping stations in the Philippines. I suggest that these sites do exist, though they are difficult to find in the literature. Many sites in the Philippines show evidence that they were used as lithic workshops as well (Latinis 1995). Whether prehistoric lithic workshops or chipping stations occurred within residential sites or separate from them needs further investigation. I suggest more scrutiny, care, and caution when assigning similar flake assemblages to the category of tool assemblages characteristic of a variety of processing activities rather than to the category of debitage assemblages resulting from specific manufacturing activities.

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ABSTRACT

Recent analyses of the lithic assemblage from the Busibus/Pintu rock shelter, northern Luzon, Philippines, indicate that this site was used as a basalt quarry and chipping station for the production of adze blanks and preforms. "Opportunistic" strategies for blank selection and preform manufacture were used. Other lithic raw materials were selected and reduced as well. It is suggested that the preforms, blanks, and reduced materials were transported, finished, and used elsewhere. Edge-wear damage analyses indicate that these materials and artifacts were not used for butchering, scraping, and woodworking, as suggested by Peterson (1974), by groups of hunters/collectors who intermittently frequented the site from about 4000 to 1500 B.P. KEYWORDS: Philippines, lithic analysis, adze manufacturing.